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Multi-technique surface analysis

Stress analysis by photoelastic testing

Selecting fillers for plastics and coatings

R&D salaries: income vs. inflation

News for and about people in R&D

Photoelastic pattern observed during bearing contact between mating parts

INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $142.5-BILLION WORLD-WIDE R&D INDUSTRY

EDITORIAL

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ABOUT THE COVER

Photoelasticity is a property of a transparent plastic object or coating. When the plastic is subjected to mechanical stress, the object or coating exhibits changes in optical properties. These changes are proportional to the stresses developed.

Polarized light passing through the stressed plastic splits into two beams. The relative phase shift between the beams yields a colored interference pattern.

Using a polariscope, the analyst can determine the principal stress directions. And, by a technique called optical compensation, can determine the magnitude of the stress.

One of the characteristics of this birefringence is the line between red and green color bands, called a fringe. The higher the fringe order, the higher the stress; the closer together the fringes, the more concentrated is the stress in the area shown.

Cover photo furnished by Measurement Group/Vishay. An article describing some practical applications of photoelastic stress analysis begins on p. 124.

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Robert R. Jones
Editor

Substantial pay increases; R&D workers make gains

There is good news in the pay checks of R&D workers who responded to the annual salary survey. Unlike last year's inflation-matching increases, this year's income levels more than keep up with living cost.

THERE'S a lot more to cheer about in the findings of this year's annual IR&D salary survey than there was in last year's. There are strong signs to suggest that workers in research, development, and quality assurance have more buying power than they had a year and more ago.

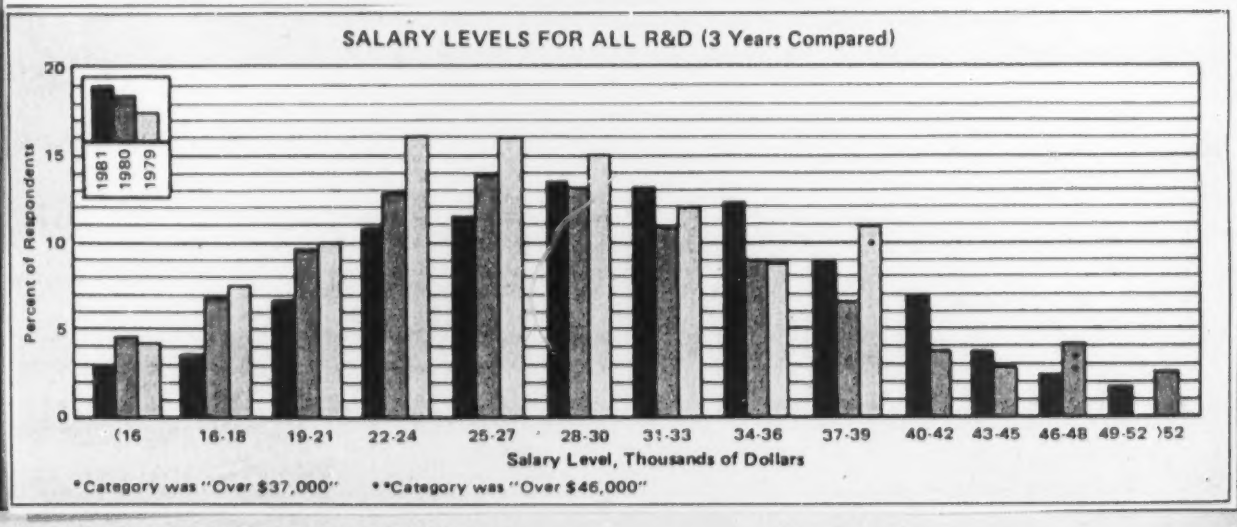
In last year's report we were forced to face up to "the very strong likelihood, if not actual certainty, that average salaries in research, development, and quality assurance have not kept up with inflation."

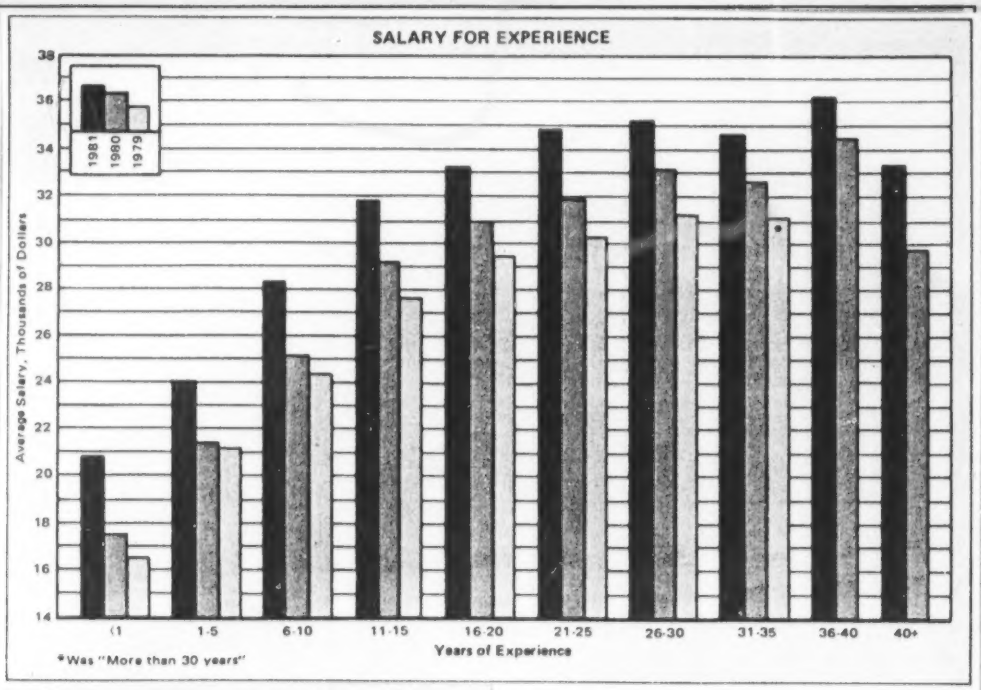
This year's responses from more than 5,850 scientists and engineers show that the entire salary framework has shifted upward by something in the neighborhood of $3,000. This is demonstrated in our chart which shows "Salary levels for all R&D, three years compared."

If you play a connect-the-dots game with the tops of the bars for each year, you will see that 1980 and 1981 (unlike 1979) make similar bell-shaped curves of the distribution of workers throughout the salary ranges. The 1981 curve, however, is offset approximately $3,000 to the right of the 1980 curve.

This little exercise tells us that the entire R&D salary framework has shifted upward. The payoff, of course, is in the individual paycheck, and we'll get to that shortly.

From 1978 to 1979, our studies have shown, the median income for R&D work-





ers increased by nearly 13%. From 1979 to 1980, the gain was only 3.5%, meaning that in most cases, individual increases derived from merit, longevity, or promotion did not add enough to keep buying power up.

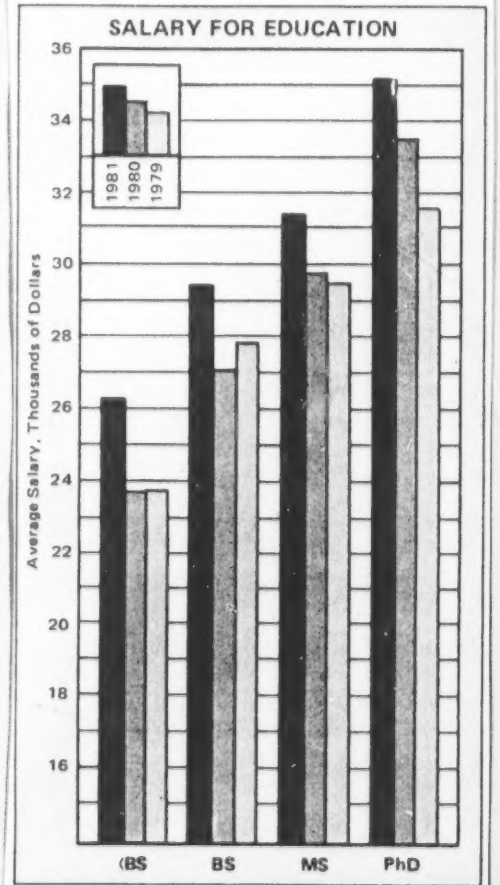
From 1980 to 1981, the industry median income has increased 9.6% and now stands at $31,221. We had used approximately that figure last year when we reported that 37.2% of the respondents were earning $31,000 or more (up from 32% in 1979 and only 13% in 1978). This year's survey finds that more than 51% now are earning $31,000 or more. The new hires coming in at the low end of the pay scale and the retirements dropping off of the high end did not keep the total scale from moving upward.

So much for the industry as a whole. For individuals, pay increases seem to be increasing at an increasing rate. More than 40% of this year's respondents received a pay increase of 10% or more during the past year—enough to keep even with inflation in most communities—compared to 1980's 28.4% and 1979's 26% who did this well. This table shows the three years for each category on the questionnaire:

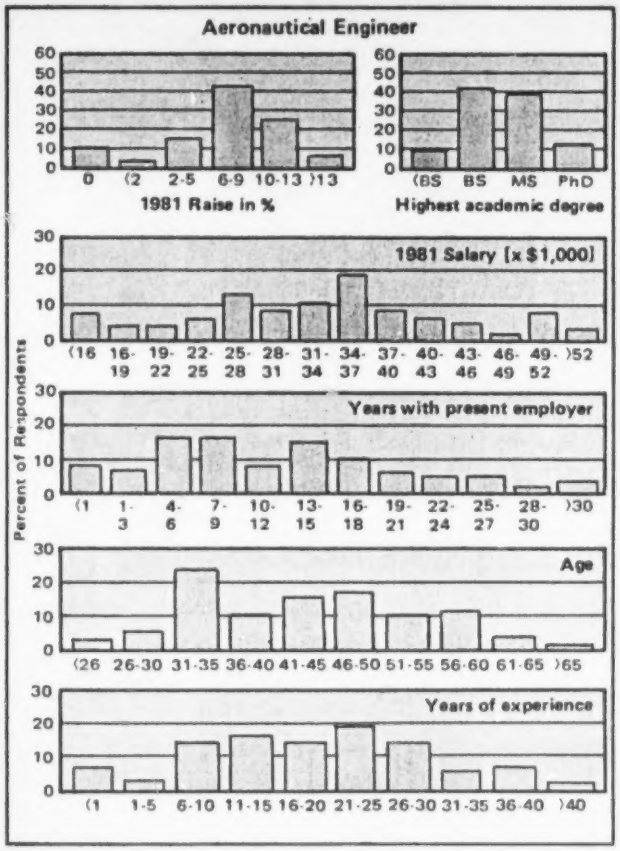
Increases in Salary: All levels R&D

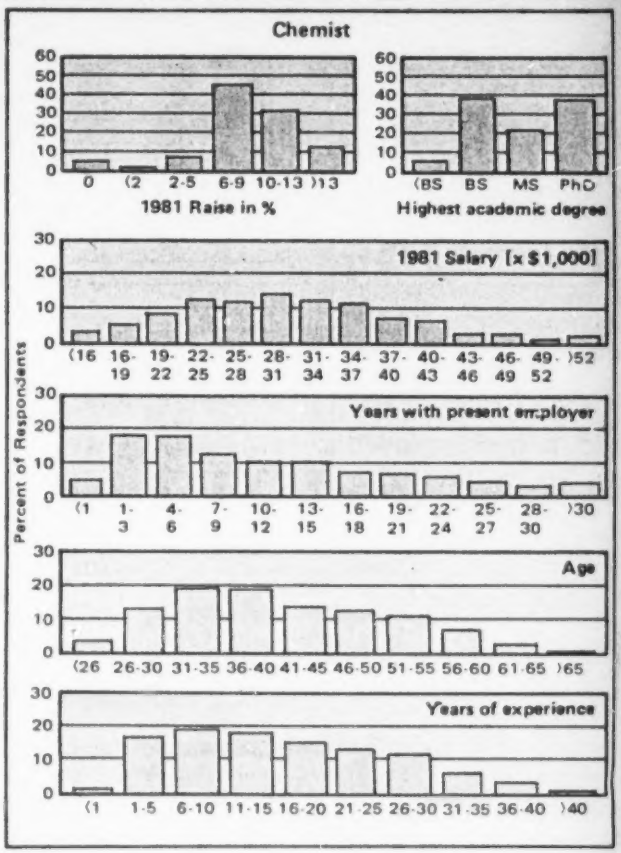
	% of respondents		
Amount	1981	1980	1979
None	5.2	5.7	5.0
<2%	0.9	1.5	1.0
2 thru 5%	8.0	12.4	19.0
6 thru 9%	45.2	52.0	49.0
10 thru 13%	29.7	19.6	20.0
14% or more	11.0	8.8	6.0
Holding even or doing better	40.7	28.4	26.0

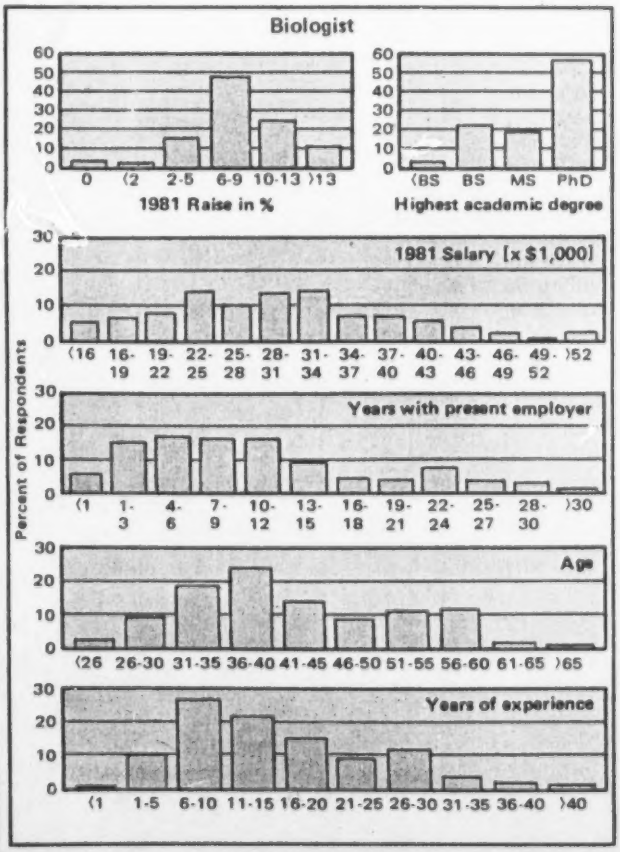
Increases were not evenly distributed throughout the professions this year any more than in past years. Chemical engineers, who had been lagging, made substantial gains. These are detailed, along with five other parameters for the different professions in the accompanying charts.



Looking at the median salary comparisons, mathematicians have stayed in







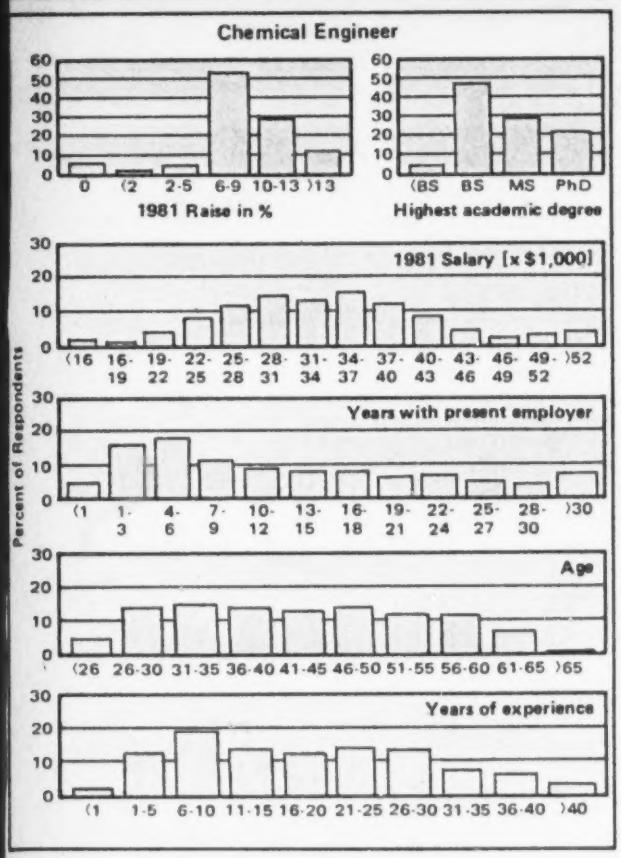
first place while biologists have advanced from eleventh to ninth. The biologists did this with a 14% improvement in their median salary. Chemical engineers logged almost as high a percentage gain, and chemists and electrical engineers held their own by making gains of 11%. Rankings by profession and relative gains are shown in a table.

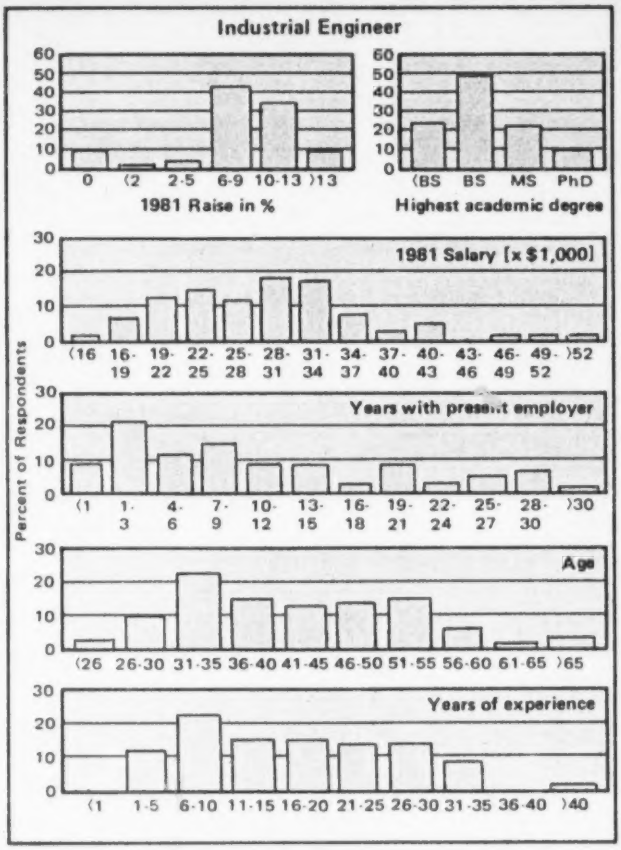
Rankings for professions by median salary

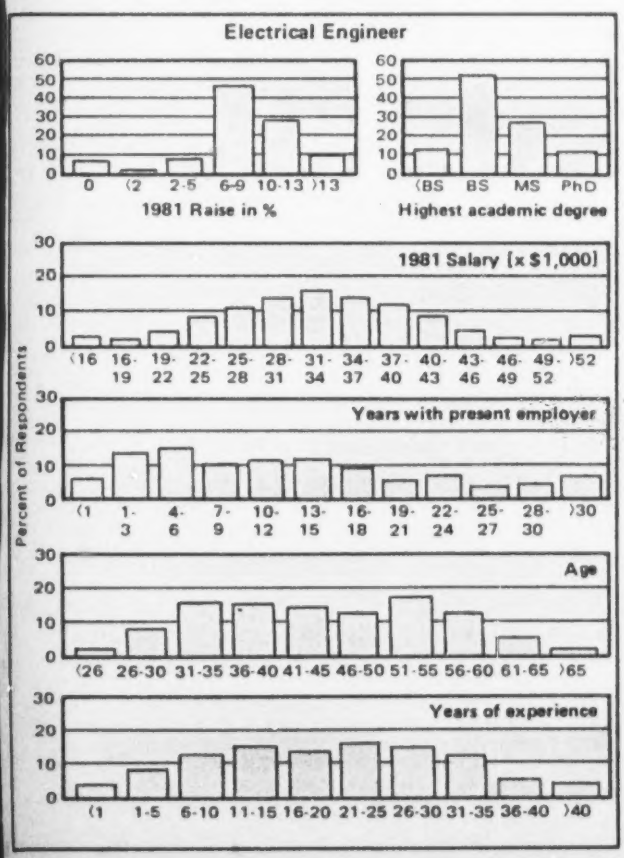
Rank 1981	Rank 1980	Profession	Median salary 1981	Median salary 1980	% increase
1	1	Mathematician	$35,750	$33,099	8.0
2	2	Aero. Engr.	33,950	32,226	5.3
3	7	Chem. Engr.	33,360	29,272	13.9
4	3	Physicist	33,180	31,050	6.8
5	5	Elec. Engr.	33,089	29,635	11.6
6	4	Metallurgist	33,054	30,228	9.4
7	6	Mech. Engr.	32,221	29,480	9.3
8	8	Chemist	30,014	27,031	11.0
9	11	Biologist	29,200	25,561	14.2
10	9	Indust. Engr.	28,750	26,649	7.9
11	10	Other	28,729	26,118	9.9

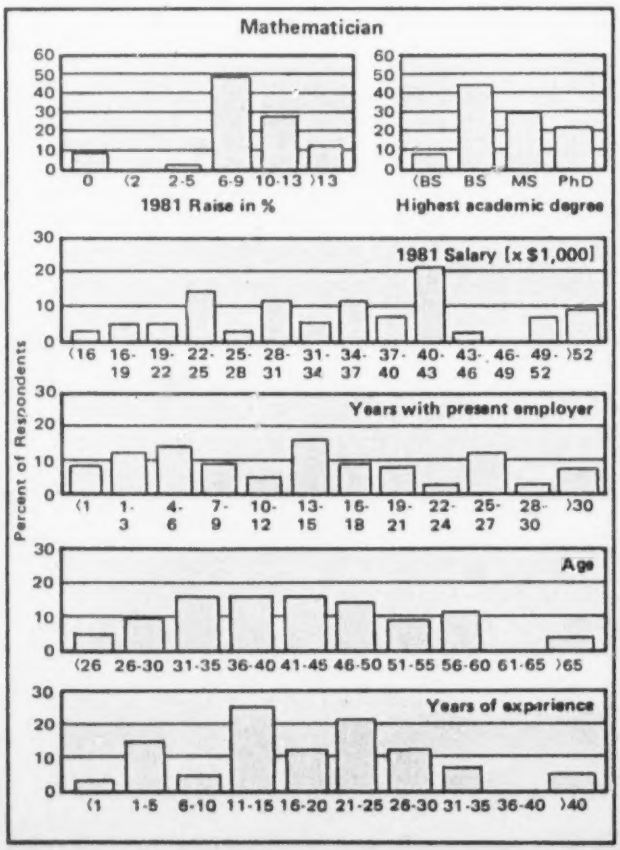
As they have in previous years, biologists lead the other professions by a large margin when it comes to the percent having doctorates. Biologists, at 56.3% PhD, are followed by physicists with 44.5, chemists 37.2, and metallurgists 32.5. Industrial engineers, electrical engineers, and aeronautical engineers have the lowest percentages of PhDs with close to 10% each.

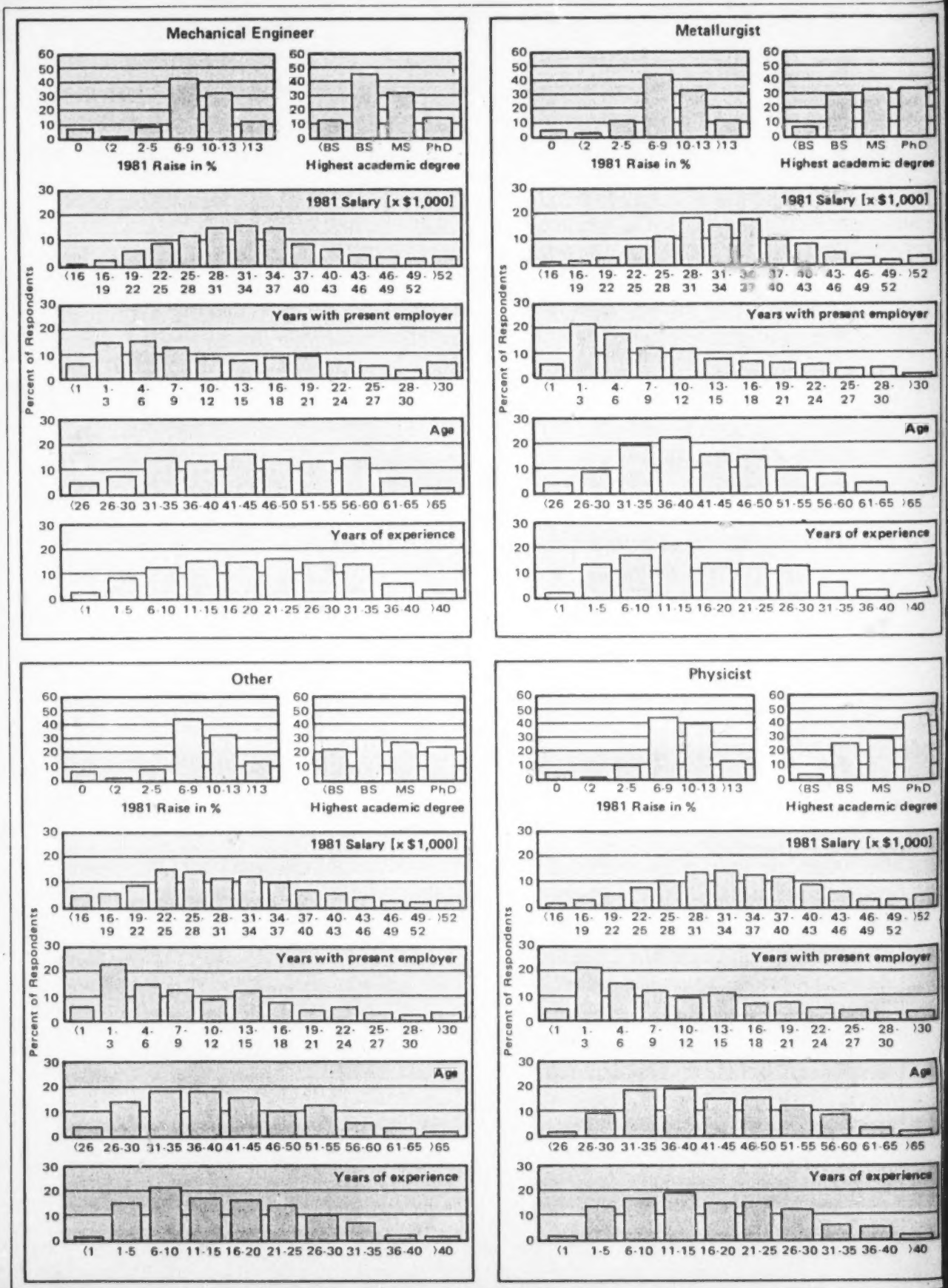
When master's degrees and doctorates are considered together and the pro-


Chemical Engineer
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents


Industrial Engineer
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents


Electrical Engineer
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents


Mathematician
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents


Mechanical Engineer
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents
Metallurgist
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents
Other
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents
Physicist
1981 Raise in %
Highest academic degree
1981 Salary [x $1,000]
Years with present employer
Age
Years of experience
Percent of Respondents

fessions are ranked for advanced degrees, biologists still lead and physicists are second, but the biologists' lead is greatly reduced. Of the biologists, 76.2% have advanced degrees; physicists are close behind with 73.2, metallurgists are third with 64.7, and chemists fourth at 57.7. Of the nearly 6,000 respondents, 54.6% have advanced degrees.

The value of an advanced degree is reflected in many ways. In dollar and cents terms, the advantages of advanced degrees vary across the professions. For our study group as a whole, median salaries by highest academic degree are compared in the table.

Salaries compared by academic degrees

Degree	Median salary 1981	Median salary 1980	percent change	Annual difference* 1981	Annual difference* 1980	Difference* increase %
Doctorate	$35,161	$32,252	9.0	$4,043	$3,876	4.31
Masters	31,118	28,376	9.7	2,105	2,067	1.8
Bachelor's	29,013	26,309	10.3	3,846	3,310	16.2
<Bachelor's	25,167	22,999	9.4	—	—	—

*Difference above next-lower degree

It is apparent that the advantages of baccalaureate and advanced degrees are increasing. The advantage in annual income for a PhD over less-than-bachelor's this year is $9,994 compared to last year's $9,253 and of the PhD over bachelor's it is $6,148 this year compared to $5,943.

We can expect the holder of a PhD to work approximately 25 years after getting that degree, as our survey shows, with the possibility of a 30-year career for the person who enters the labor force after obtaining a BS. Assuming that an 8% interest rate prevails over this 25-year career, the advantage of the doctorate over an MS is close to $320,000. MS holders would outdo those with only a BS by better than $165,000. A BS compared to no college degree pays off to the tune of more than $300,000.

Projected on the bases just stated, the advantage in the annual salary for a PhD when compared to a bachelor's would provide a career gain of more than $485,000.

Allowing the BS holder five additional income years (while the PhD candidate hits the books), and making adjustments for interest, tuition, etc., etc., worth possibly $195,000, the advantage of the PhD still is in the neighborhood of $290,000—not a bad return for those five years in grad school, since the income is only one of the possible benefits from the degree.

The annual income advantage of a doctorate has increased steadily since 1978 when it was on a plateau, having been in the $2,000-range for three years. In 1979 the advantage was $3,300; 1980's was $3,876, and this year, as noted above, it is more than $4,000.

This fact is emphasized by the information in the following table which shows percentages of degrees in selected salary ranges for all respondents.

Distribution of degrees for all respondents and in selected salary ranges

Category	<BS	BS	MS	PhD
All R&D	7.9%	37.4%	25.3%	29.4%
$19,000 to $21,999	14.3	51.7	27.1	6.9
$40,000 to $42,999	3.7	24.6	23.1	48.6
$43,000 to $45,999	2.9	19.5	27.6	50.0
More than $46,000	4.4	24.9	22.1	48.6

We would expect the percentages of degrees to be the same in each column if academic accomplishment were not a salary factor.

In the second part of this salary report we will present the salary picture as provided by the same nearly 6,000 respondents when broken into categories of sex and workplace.

When you read that second article you will see that other important changes are occurring in the R&D industry that may affect you and your work. □